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A KANTIAN PERSPECTIVE ON THE SOCIAL RATE OF DISCOUNT

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A Kantian Perspective on the Social Rate of Discount

For an intertemporal choice rule based on discounting to be acceptable it must satisfy some properties of desirability. The purpose of this paper is twofold. First is that it considers four such properties in the context of the Sen-Marglin-Lind social rate of discount [8, 7, 6, 9, 10]: intertemporal efficiency, intertemporal equity, intratemporal efficiency, and intratemporal equity. Second, it recasts the problem of intertemporal choice in the more general framework of intertemporal social choice, focusing primarily on the intertemporal equity aspects of the problem. In this paper the problem of intertemporal equity is viewed as the aggregation problem in intertemporal social choice. In this context, intertemporal equity can be approached in terms of the axioms that define the aggregation rule F or of limitations to the feasibility set E, or a combination of both.

Definition of the Social Rate of Discount. In the Sen-Marglin-Lind (SML) discussion a dichotomy arises between the private rate of discount and the social rate because there are externalities associated with the savings effort undertaken by members of the present generation. I benefit from my contemplation of saving for the next generation, but I also benefit from my contemplation of the saving by each of the other members of the present. Likewise each of the others in the present benefit from the contemplation of saving by the rest. In the atomistic case, where there is no collective savings rule and each saving decision is made in the absence of cooperative agreement among members of the present generation, there will be some saving. But in the case where a collective

savings rule can be agreed upon, each in the present will save a little more, and all in the present will be better off.[1]

The analysis is made considerably easier by positing that there is a world of equals in the present generation, with each Mr. i in the present having the same utility function and the same resource endowment. In this case various savings efforts can be put up for a majority rule vote and the most advantageous to one will be the most advantageous to all, so that a collectively chosen savings effort can be agreed upon unanimously. In the case where it is institutionally feasible to reach and enforce a savings effort of each Mr. i conditioned upon the (same) effort of each other Mr. i, the social rate of discount is defined by

$$1 + \rho = \left.\frac{\Delta \text{ future consumption}}{\Delta \text{ present consumption}}\right|_{\substack{\text{utility Mr. i constant;}\\ \text{collective savings rule}}} \qquad (1)$$

In the case where it is not institutionally feasible to establish a collective savings rule, the private rate of discount is defined by

$$1 + \pi = \left.\frac{\Delta \text{ future consumption}}{\Delta \text{ present consumption}}\right|_{\substack{\text{utility Mr. i constant;}\\ \text{no collective savings rule}}} \qquad (2)$$

Defeat of the Lambda Rule of Distribution

Following Sen, [9] each Mr. i attaches, at least on the margin where the decision is being made, a weight of

1 per unit his own consumption today,

β per unit consumption of others today,

γ per unit consumption by his heirs, and

α per unit consumption by others in the next generation.

As an institutionally chosen constraint, not under control of members of the present generation, λ is the fraction of the savings product of Mr. i's effort that goes to his heirs; the rest goes to others in the next generation. N_1 denotes the set of individuals belonging to the present generation; N_2 denotes the next generation. There are N individuals in each.

In Sen [9] the savings problem is viewed as a game among the N members of the present generation. Without a collective savings rule, there is a Nash equilibrium, which is non-Pareto optimal. The purpose of the collective savings rule is to change the game into a cooperative one, which is Pareto optimal. However, it is also possible to view the matter as a game between the present generation and the next generation, as well. In this light the purpose of the collective rule of savings is to defeat the λ rule of distribution.

Consider a unit saved by i in the present generation, without a collective savings rule. The fraction λ of it goes to his heirs and $(1-\lambda)/(N-1)$ goes to each of the others in the second generation. As long as α is less than γ, (Mr. i values his heirs' consumption above others' in the future) individual i will prefer larger λ to smaller λ, (and he prefers most of all that $\lambda = 1$ in which case his whole unit effort goes to his heirs). Under the collective rule of savings λ of his unit goes to his heirs directly and $(1-\lambda)/(N-1)$ to each other individual in the second generation. However, under the collective rule of saving, i's act of saving is tied to all others' saving in the first generation. For each of these others, $(1-\lambda)/(N-1)$ goes to i's heirs. There are (N-1) others in the first generation saving, hence i's heirs pick up in total from savings other than i's equal to $(N-1)(1-\lambda)/(N-1)$ or $1 - \lambda$. So the total effect of i's unit saving, under the collective rule is $\lambda + (1-\lambda)$ going to his heirs. In other words the collective rule of savings guarantees that a unit saving from i in the present generation results in a unit going to i's heirs no matter what the λ rule of distribution. The situation is symmetric for all

the individuals in the present. As far as each member of the first generation is concerned, his unit saving effort is translated by the collective savings rule into a unit consumption for his heirs. The λ rule of distribution is defeated.

But the purpose of the collective rule of saving is more than to defeat the λ rule of distribution solely. To develop this idea, write Mr. i's utility function, with no essential loss of generality to the SML discussion:

$$U_i = C_i + \beta \cdot \sum_{j \neq i} C_j + \gamma \cdot \sum_j C_{ij} + \alpha \cdot \sum_{j \neq i} \sum_k C_{jk} \qquad (3)$$

where C_i is individual i's own consumption, in the present

C_j is individual j's own consumption, in the present

C_{ij} is the consumption of i's heirs coming from individual j's investment

And to close the model explicitly we further specify an equal initial endowment for each individual i in the present, K; and an investment function:

$$K_i = f(S_i)$$

where K_i is the investment product available for consumption in the second generation, from i's saving in the present generation

S_i is the savings of individual i in the present generation

$$S_i + C_i = K, \text{ all } i.$$

Without a collective savings rule individual i acts to

$$\max_{C_i} U_i = C_i + \beta \cdot \sum_{j \neq i} C_j + \gamma \sum_j C_{ij} + \alpha \sum_{j \neq i} \sum_k C_{jk}$$

subject to:

$$C_{ii} = \lambda f(K-C_i)$$

$$C_{ji} = (1-\lambda) f(K-C_i)/(N-1), \ j \neq 1$$

Thus each Mr. i in the present geneation sets

$$\frac{1}{\lambda\gamma+(1-\lambda)\ \alpha} = f', \tag{4}$$

or the marginal efficiency of capital to the private rate of discount, (2).

With a collective savings rule individual i acts to maximize the same utility function, again over C_i, but over different, institutionally determined constraints; namely,

$$\sum_j C_{ij} = f(K-C_i) \quad \text{(defeat of } \lambda \text{ rule)}$$

$$\sum_{j\neq i} \sum_k C_{jk} = (N-1)f(K-C_i)$$

$$\sum_{j\neq i} C_j = (N-1)\ C_i$$

Thus each Mr. i in the present generation sets

$$\frac{1+(N-1)\beta}{\gamma+(N-1)\alpha} = f' \tag{5}$$

or f' equal to (1).

Note that in the "normal" case $\gamma > \alpha$, and when $\alpha/\beta > \gamma$

$$1+\pi = \frac{1}{\lambda\gamma+(1-N)\alpha} \geq \frac{1}{\gamma} > \frac{1+(N-1)\beta}{\gamma+(N-1)\alpha} = 1+\rho$$

So even if λ were initially set equal to 1, so that there were no need to defeat the λ rule of distribution and $1+\pi$ equalled $1/\gamma$, the private rate would still be greater than the social rate and there would still be an incentive to have a collective savings rule. The case where $\lambda = 1$ and $\alpha/\beta = \gamma$ is where all one's inheritance goes to one's heirs and there are "balanced emotions." In this case there is no incentive for those in the present generation to institute a collective savings rule and $\rho = \pi$. In the case where $\alpha/\beta = \gamma$ but $\lambda < 1$, the only reason for instituting a collective saving rule is to defeat the λ rule of distribution.

Consideration Set

Definition: The consideration set is the set of individuals over which Pareto comparisons are made.

Note that the consideration set for the SML social rate of discount is the present generation (N_1). Preference structures have been established only for the members of this generation.

Intratemporal Efficiency of the SRD

The allocation associated with a collective savings rule and a savings effort defined by equating the social rate of discount to f' is Pareto optimal over the consideration set N_1. This result is already established in [8, 7, 6]. Of course there are many Pareto optimal allocations, each one associated with a redistribution of the initial endowment K. Even with differing wealth positions there will still be unanimous agreement on the level of f' but the actual savings will differ from individual to individual with the differing endowments after transfer (unanimity preserved because the utility functions are linear in K).

Intertemporal Inefficiency of the SRD

Because the consideration set for the SML social rate of discount is not $N_1 \cup N_2$, this notion of a discount rate is not one of intertemporal efficiency. The optimality of this rate of discount is defined in terms of the Pareto optimality over N_1. Thus it is possible to define preference structures for N_1 and N_2 such that there is an intertemporal conflict of interest, which, with the existence of certain institutions, could be resolved to the mutual advantage of both generations.

So far the collective rule of saving has defeated the λ rule of distribution costlessly, at the same time achieving resolution of the potential intratemporal inefficiency of "unbalanced emotions." To focus on the potential conflict of interest across generations, consider a special case of balanced emotions, where $\alpha = \beta = 0$. In this case the sole purpose of the collective rule of saving is to defeat the λ rule of distribution. In order to generate an intertemporal conflict of interest, the utility function of each $i \in N_1$ is modified so that defeat of the λ rule of distribution comes at a cost to those in the first generation. We assume that it means more to Mr. i that his heirs receive a unit of consumption from his own savings effort than from a unit from someone else's saving effort. Blood lines count for Mr. i, and in fact blood donation may be a practical example. It appears that many people receive more satisfaction in their relatives receiving their own blood rather than an equal amount of others' blood. Let the utility of each Mr. i in the first generation be

$$U_i^1 = C_i + \gamma C_{ii} + \gamma\delta \sum_{j \neq 1} C_{ij} \text{ where } 0 \leq \delta \leq 1 \tag{6}$$

Because the preferences of members of the second generation have so far been left entirely unspecified, we have complete freedom in defining their preferences in such a way that might generate a conflict of interest between generations and consequently intertemporal inefficiency. Such a conflict can arise in a very simple manner. Suppose that members of the second generation have a weak preference toward egalitarianism. If they were completely egalitarian they would insist on $\lambda = 1/N$, but all we need is a weak preference for λ to be less than 1. As a second divergence of preference, each individual of the second generation does not care whether he consumes one type of consumption good or another, the sum total of the consumption goods is all that matters to him. We can specify the utility function of each members of the second generation as follows:

$$U_i^2 = \sum_j C_{ij} - (\lambda - .5)^2/1000 \tag{7}$$

Members of generation one control the saving-investment decision and the institutional constraint of whether or not there is collective saving.

Members of generation two control the institutional constraint defined by the λ rule of distribution. Now we are ready to reconsider the question of Pareto optimality, this time for the consideration set $N_1 \cup N_2$. We identify three cases.

Case 1. No collective savings rule available to generation one, generation two controls λ. In case 1 each Mr. i of the first generation maximizes (6) over C_i subject to

$$C_{ii} = \lambda f(K-C_i),$$

leading to the first order condition

$$f' = \frac{1}{\lambda\gamma}. \tag{8}$$

And the representative individual in generation two maximizes over λ with the result that generation two unanimously chooses $\lambda = 0.5$.

Case 2. Collective savings rule available, generation two controls λ. In case 2 each Mr. i of the first generation maximizes (6) over C_i subject to

$$C_{ii} = \lambda f(K-C_i)$$

$$C_{ij} = (1-\lambda)f(K-C_j)/(N-1)$$

$$C_j = C_i,$$

leading to the first order condition

$$f' = \frac{1}{\gamma\lambda + (1-\lambda)\gamma\delta} \tag{9}$$

and again generation two chooses $\lambda = 0.5$.

Case 3. Generation two gives up the λ rule of distribution, and sets $\lambda = 1$. In this case there is no advantage to either generation one or two, whether or not the collective rule of savings is available. Mr. i of the first generation maximizes (6) over C_i subject to

$$C_{ii} = f(K-C_i)$$

with the resulting first order condition

$$f' = \frac{1}{\gamma}. \tag{10}$$

We can call (10) an intertemporal rate of discount, because it is based upon the preferences of both generations, taken together. With $0 \leq \lambda \leq 1$ and $0 \leq \delta \leq 1$, we have

$$\underset{\text{private rate}}{\frac{1}{\lambda\gamma}} \geq \underset{\text{social rate}}{\frac{1}{\lambda\gamma + (1-\lambda)\gamma\delta}} \geq \underset{\text{intertemporal rate}}{\frac{1}{\gamma}}$$

It is easy to check that the intertemporal rate of discount can lead to allocations which Pareto dominate both the private rate of discount and to the social rate of discount. To see this we can take the numerical example:

$f(S) = 7S - (1/2)S^2$

$\gamma = 1/2$

$K = 17$

$\delta = 1/3$,

(and $\lambda = 1/2$, case 1 and case 2; $\lambda = 1$, case 3).

TABLE 1

	Case 1 Private	Case 2 Social	Case 3 Intertemporal
f' (to be equated with the discount rate)	4	3	2
Saving by Mr. i, present generation	3	4	5
Utility, each Mr. i present generation	19.5	19.7	23.3
Utility, each Mr. i future generation	16.5	20.0	22.5

In the numerical example the social rate of discount (3-1=2) is smaller than the private rate of discount (4-1=3), and the allocation, for the entire community of present and future, under the social rate of discount (associated with collective savings) Pareto dominates the allocation under the private rate of discount (without collective savings). However, the intertemporal rate of discount (2-1=1) is in turn smaller than the social rate and its implied allocation Pareto dominates the one under the social rate.

In order to promote the kind of intertemporal efficiency just discussed there need to be institutions which lead to the wishes of the past being honored and the needs of the future anticipated. The present undertakes some action to the benefit of the future on the faith that the future will change its behavior because of the action. Traditions of common law, the law of wastes, contract law, and legislative acts have the essential purpose of bridging time. Contracts can only be signed and agreed upon by members of the same instant, but the purpose of a contract is to change future behavior on the basis of present action. If there were no faith in the intertemporal "momentum" associated with contracts, there would be no usefulness to them. Thus a number of institutions can be analyzed (and some of them justified) on the basis of how they may or may not promote intertemporal efficiency.

Intertemporal Equity and the SRD

"Equity" is a relatively undefined term, suggesting different things to different people, and "intertemporal equity" is perhaps even vaguer. However, as a start we may say that intertemporal equity is the "fair" resolution of conflicts of interest across time. This does not appear to get us anywhere, because "fair" is still undefined, but it helps. First of all, to have a problem of intertemporal equity, there needs to be a conflict of interest. If some of the interests are left out of consideration altogether, then there can be no "fair" balancing of interests and hence no satisfaction of a concept of intertemporal equity, no matter what the definition of "fair." In defining and applying the SML social rate of discount, the interests of those in N_2 are not defined and brought into the analysis. Thus this notion of a social rate of discount is independent of a concept of intertemporal equity.

Although people differ as to what they think is "fair," they often agree on specific examples that they think are "unfair." Thus to illustrate the independence between the notions of the SRD and intertemporal equity, we may look for an example in which application of the SRD leads to an allocation inconsistent with "almost anyone's" sense of fairness. To do so it is not necessary to look for conflicts of interest in which both generations gain by their resolution; in a sense efficiency increasing resolutions are not resolutions of conflicts at all, but simple horse trading. We go back to (3) and look at the case where

$\beta = 0.8$

$\gamma = 0.25$

$\alpha = 0$

$\lambda = 1$

$K = 17$

$N > 1.$

This time suppose that there are not just two but many possible generations, each with population N and with the same utility function (3) for each individual in each generation. With respect to the preference structures we are in an intertemporal world of equals. However, some

generations have the advantage (or disadvantage) of being born earlier than others, so that the use of the original resource base NK may not appear to some generations, or to the atemporal observer.

If no collusive, cooperative agreement is allowed among the members of a single generation then (2) applies and it is easily checked that the path of consumption grows from 14 percapita in the first generation to 14 1/2 in the next, from whence it remains forevermore constant (the economy is permanently sustainable at 14 1/2 consumption percapita). But if a collective rule of savings is allowed, percapita consumption is 17 for the first generation, there is no saving, and there is zero consumption for all the other generations. The first generation did not create or earn its original endowment of NK. In a sense this resource base is the "common heritage of all generations," and the first generation happens to be its first trustee, by virtue of being born first -- by the happenstance of time. To the atemporal observer this "unnecessary" running down of the resource base appears intertemporally inequitable. (It should be noted that application of the SML social rate of discount does not usually lead to such perverse allocations compared with the private rate of discount. Indeed this notion of a social rate of discount appears to have been developed in order to encourage greater investment in underdeveloped countries, for the benefit of the future, not to its expense. The point here is that there is nothing in this concept of a social rate of discount to guarantee the preservation of the resource base, and this observation applies as well to other concepts of the discount rate based on the present's sense of time preference.)

Intratemporal Equity and the SRD

The present impasse in the development of energy policy results in large part from disagreements about intratemporal equity -- who in the present should bear the burden of conservation, and how the impact of higher prices can be softened for those least able to pay. Regional disputes over heating oil for the northeast, diesel fuel for the midwest and gasoline everywhere have slowed the development of common policy.

"Intratemporal equity" can be taken to mean the "fair" resolution of conflicts of interest among members of a single generation. Because of the posited world of equals in the SML social rate of discount, unanimous decisionmaking is possible and there is no conflict of interest over a collective decision on the savings effort (f') for each individual. Although unanimity remains when the initial endowment is made to vary among individuals, unanimity is lost if α, β and γ are made to vary as well. With differing α, β and γ, people will have differing opinions as to the optimum collectively chosen savings effort (or efforts). There is no easy resolution of this conflict of interest over the level of savings effort.

For the case of differing α, β and γ among individuals of the same generation, Sen [10] suggests weighting the benefits of each group (or individual in the present generation). Each possible set of weights amounts to the selection of one Pareto optimal allocation, over the consideration set N_1, from the infinitely many possible Pareto optimal allocations (also over N_1). In other words setting the weights amounts to solving the problem of intratemporal equity. If we had the set of weights we could define the social rate of discount. But the SML social rate of discount gives no insight as to how the weights, or some other scheme of aggregation could be chosen. Thus this notion of the social rate of discount does not include a concept of intratemporal equity.

Of the four properties of social desirability -- intertemporal efficiency, intertemporal equity, intratemporal efficiency and intratemporal equity -- we would not expect a single concept of the discount rate translated into a single number to satisfy all four. There would be a targets-and-instruments problem. This is the "discount rate problem" -- that a single concept, specified as a single number, cannot satisfy several goals simultaneously (see Baumol [2]). Before analysis, we might expect that a concept of the social rate of discount might lead toward a combination of the four. But we have seen that the SML notion is precisely defined in terms of intratemporal efficiency, and is conceptually independent of the other three.

In order to bring the desirability properties of intertemporal efficiency and intertemporal equity into a common framework of discussion, the notation of social choice is used below. But refocusing the discount rate problem this way comes at a price of its own. We assume below that the intratemporal choice problem has been "solved." Each generation acts like a single unit and we drop our concern for the intratemporal aspects of the decision problem in favor of the intertemporal.

Intertemporal Social Choice

Let x_t be a description of the conditions under which generation t lives and $x - (x_1, x_2,\dots,x_t,\dots)$ be the state of the world from now on. The collection of feasible states is $E = (E_1,E_2,\dots)$, where E_t is the set of feasible options for generation t. Clearly a choice of x_t at time t may constrain the generational opportunity sets from t on. R_t is a weak order specifying the preference structure of generation t. We often think of a generation as the lifetime of an individual, and generations as overlapping. But for this discussion we can think of a generation as a single year, generations not overlapping, but a single individual belonging to a number of generations. The intertemporal social choice problem is to select an aggregation rule F

$$F: (R_1, R_2, \ldots, R_t, \ldots) \rightarrow R$$

Must the first generation (the present generation) be an intertemporal dictator? In some ultimate, de facto sense, the first generation is a dictator, because there is no other genration in existence to help make the choice. However, the first generation need not be a dictator in the Arrow sense.[2] This possibility result is a direct corollary of the theorem by Hansson (see [4] for discussion) which states that when there are an infinite number of voters the Arrow axioms of Pareto, Irrelevant Alternatives, and Transitivity are consistent with an infinite number of social choice aggregation rules that are non-dictatorial. All that needs to be done to establish this corollary is to interpret the voters as generations.

On what basis is F to be chosen? The selection of F can be viewed as the problem of intertemporal equity, in which the specific and potentially conflicting interests of the individual generations, described by the R_i, are harmonized and resolved into the single intertemporal preference order R. It is possible to select F, not in terms of the specific interests of the first generation or any other generation, but in terms of the appeal of the axioms that define F. Going further, in the Kantian tradition defining a just or fair rule <u>depends</u> upon first setting aside one's own specific interests in the matter. The appeal of the Arrow axioms is not in how they make a particular voter better or worse off in a particular situation but in their symmetry in dealing with the arbitrarily defined general profile of voter interests. By choosing the Arrow axioms, or other axioms, it is possible to define F without knowing the specific interests of specific generations. Kant would say that in trying to select a fair or just F, it is <u>better</u> not to know the specific interests of one's own generation. One does not need to know the specific interests

of the other generations either -- both being necessary for a utilitarian approach. For the Kantian tradition, in trying to specify a just rule, to take into account what one gains or loses by the rule is to poison the process of selection.

Putting the matter another way, in the Rawlsian version of this tradition, an intertemporally fair rule is one that would be chosen if all the generations were present in an original position under a veil of ignorance as to their specific interests (see [2]). At the abstract level, we may ask what would be the F implied if the representatives in the intertemporal original position considered the Arrow axioms. As shown in Ferejohn and Page [4], these axioms in the intertemporal setting imply a class of social choice rules which all embrace some of the properties of majority rule voting. Unfortunately such social choice rules are strongly time asymmetric, because all the infinite majorities lie in the asymptotic future. Under a veil of ignorance, in which each generation does not know its place in time, this situation might seem unfair. Nonetheless, some of the character of this type of rule might be attractive to those in the original position. For example, they might find attractive a "finite version" of this rule which says that if the present generation prefers x to y, but if the forseeable future -- the next five or ten generations realistically -- prefer y to x, then x should not be chosen. Note that at the level of selection of the rule, no generation knows its own interest as no generation knows its place in time, so that specific interests are irrelevant to the process of selecting the rule. But once selected, the application of the rule depends upon trying to calculate the interests of the various generations.

This "finite version" rule has application to situations where there are potentially long term irreversibilities, such as release of long lived radioactive wastes and chemical mutagens. We may not know the future's preference structure in detail, but we can be reasonably certain that they prefer less cancer to more. This last observation does not mean that the rule would imply that there be no nuclear power plants or that unlimited safety should be built into any that are built. There are other benefits associated with a nuclear program, and there comes a point in a safety program where the future benefits more from resources expended in other activities than in additional safety. But this "finite version" rule is indeed different from a discount rule as an intertemporal social choice mechanism, and tends to be more cautious toward irreversible harm.

Should the intertemporal social choice rule F be defined to be a discount rate rule? Notationally should we require

$$xRy \iff \sum_{i=1}^{\infty} \delta^{i-1} U(x_i) \geq \sum_{i=1}^{\infty} \delta^{i-1} U(y_i) \text{ for some fixed } \delta \text{ between 0 and 1?}$$

The usual reason for advocating a discount rule to be the intertemporal choice rule is that it is intertemporally efficient. As we have seen, where there are intratemporal externalities the private rate of discount may not be intratemporally efficient, and where there are intertemporal externalities the social rate may not be efficient. The usual argument about the intertemporal efficiency of a discount rate rule assumes away these kinds of externalities and focuses on the efficient mix of a several good economy, where the goods may have different marginal productivities at different levels of use [3, 5, 1]. In such situations a discount rate based on the opportunity cost of capital, allocated over the production of several goods, is needed to rule out intertemporally inefficient paths.

However, if we consider the alternative collection of rules implied by the Arrow axioms, each of these are intertemporally efficient too, because Pareto is one of the axioms. Thus if efficiency is our only concern, we have no basis upon which to choose between the intertemporal voting type of rule and the discount rule. The two types of rules are different and can rank alternative decisions differently, so we need to look at the matter a little further.

The first thing to note is that even if we refuse to accept the discount rule as the intertemporal choice aggregation rule, discounting is not abandoned altogether. Indeed it is already embedded at two other levels of the choice problem. A discounting concept in the form of the opportunity cost of capital helps define the intertemporal feasibility set E. And a discounting concept in the form of time preference, one for each generation, is embedded in the preference ordering R_i for each generation (each generation has preference orderings over the entire path $(x_1, x_2, \ldots)$ and not just over alternative snapshots of its own particular time (x_i). Having already two roles in the intertemporal social choice aggregation problem, requiring the third may be a bit greedy.

The second thing to note is that one of the necessary properties of a discount rate rule, as the intertemporal aggregation rule, is stationarity. As shown in [4] this property, in the context of the Arrow axioms, also has a strong time asymmetry. Adding stationarity to the Arrow axioms not only forces the aggregation rule to be dictatorial, but also picks out the first generation to be the dictator. Thus in adding stationarity to the Arrow axioms we lose the Kantian concept of fairness.

It is unlikely that there will be a universally agreed upon notion of intertemporal equity or of the means to satisfy the notion. The situation intertemporally is a little like the debate over the progressive income tax intratemporally. Different people have different ideas as to how progressive the income tax should be, and in part these differences rest upon different ideas about intratemporal equity. There is a continuing debate and the actual level of progressivity results from the political outcome of the debate. The usefulness of an analytical discussion is mainly to provide a more explicit framework for the debate. In this spirit we can identify two possible directions toward which a concern for intertemporal equity could lead.

(1) Speaking loosely, the Arrow axioms by themselves and stationarity plus the Arrow axioms span the time space, with the Arrow axioms giving decision power to the asymptotic future and the Arrow axioms plus stationarity giving decision power to the present. It would be useful to investigate other axiom systems that are not so time asymmetric in either direction.

(2) Another approach would be to restrain the domain set for the R_i or restrain the feasibility set E, ruling out certain choice alternatives as a matter of intertemporal equity before choosing F. One of the traditional ways of dealing with the Arrow paradox is to constrain the domain set. Alternatively if certain alternative paths are ruled out from the beginning, like collapse of the resource base, then discount rate choice rules may be more acceptable on equity grounds.

Stiglitz [11] has suggested that if we are interested in improving the lot of the future, on the grounds of equity, then we should use generalized instruments like lowering the market rate of discount to do so. However a couple of questions arise here. The market rate of discount

serves several functions intratemporally and traditionally manipulation of the rate has been undertaken for the purposes of controlling inflation, relieving unemployment, and controlling the international flow of currencies. Just in the short term, intratemporal setting there is a targets-and-instruments problem in which manipulation of interest rates is unable to do all desirable things simultaneously. Second, if interest rates were lowered, for the purpose of benefitting the future, it is not clear that the future would in fact benefit. With respect to energy, the problem facing the future is that as present supplies become depleted there is the risk that future substitutes will not be developed in a timely fashion. A main purpose of conservation is to relieve this risk burden, by buying time (a second purpose is intratemporal -- to relieve our short term dependence on foreign suppliers). Other problems facing the future have to do with population growth, depletion of soils, heat limits to the dissipation of energy consumption on a worldwide scale, and so on. It is possible that stimulating investment generally will intensity rather than ameliorate these problems. It is conceivable that subsidy of the profit rates for synthetic fuels, along with other subsidy of interest rates, for example, could lead to situations where 10 BTUs are spent trying to recover 9.

As an alternative we can face the intertemporal equity problem directly by specifying targets of what we would like the resource base to look like, as a matter of equity, 25, 50, and 100 years from now. There is both a normative and a practical reason for focusing specifically on the resource base rather than something more general such as the wealth position of succeeding generations. We did not earn or create the resource base we inherited, we were born into it. Locke would say that we acquire just ownership over that part of the resource base which we mix our labor with, and appropriate from the commons. But at the time of Locke, the commons was sufficiently large so that appropriating one part of it still left more for others. The situation with respect to energy and some other natural resources is now different. If our claim to the ownership of the natural resources is based upon the happenstance of time -- that we are born earlier than following generations and that previous generations did not have the technological power to destroy the resource base in their own time -- then this claim is pretty thin. However, if we use the resource base in usufruct, replenishing it through substitutes and the return to renewable resources as we deplete the nonrenewable ones, then our claim to the man-made capital and other wealth gained from mixing our labor with the services in usufruct of the inherited resource base appears much stronger. Our obligations to the future have to do with the means of survival, with the resource base which we inherited, rather than with the fruits of our efforts.

Intratemporally, at a normative level, we may wish to guarantee that no one starves, that anyone is entitled to a reasonable opportunity of education, basic medical care, and legal counsel before the court. But we may at the same time feel no obligation to guarantee everyone the same wealth, education, health, or chance of winning in court. Our idea of equity can extend to certain opportunities but not so far as to guarantee the results of these opportunities. And so it is across generational time. We can feel the obligation to guarantee the means of survival by preserving the capacity of the resource base, but we may not feel the obligation to guarantee a specific wealth position for the future.

As a practical matter, it is much easier to provide for certain opportunities than it is to insure their results. We do not know in detail the preference of the future and we do not know how well or how hard those in the future will work. We have little control on their actual levels of utility. But we do have a large measure of control over the adequacy of the resource base which they will inherit. We can ambiguously increase conservation and the payoff to substitutes by instituting a system of taxes on the extraction of virgin materials and we can lower the risk that substitute technologies will not appear to replenish depleted resources by investing directly in the substitute technologies. We affect the adequancy of the resource base by our population policy. Our choice of x_1 in the present affects the $(E_2,E_3,\ldots)$ in the future.

In optimal control problems, choosing the terminal stock is often looked upon as an embarassment. Usually the functional being maximized is some sort of present value, and the discount rate involved here gives no clue as to how to evaluate the terminal stock, whose value is determined "beyond the terminal date." For this reason many analyses put off the terminal date to infinity where it does not matter. However, the above analysis suggests that doing so puts out of consideration the most interesting part of the choice problem. We can view the problem of choosing the terminal stock as the problem of choosing an intertemporally fair target. There need not be just one target at the end of the planning period, but several targets, or check points along the way. These targets can be thought of as requirements of resource adequacy along the control path. If these targets are to be reached along the way, and if they are thought to be intertemporally equitable, then the objections to the discount rule as the intertemporal choice rule largely disappear.

Footnotes

[1]As noted by Sen [9] a collective savings rule does not imply greater savings effort. We make use of this non-implication below.

[2]In the Arrow sense, the first generation is a dictator if generation one's preference of x to y implies the intertemporal social preference of x to y.

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